# DEVELOPMENT OF SOLAR POWERED NOTEBOOK

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"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Power Systems)"

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# ABSTRACT

The Notebook powered by it battery is convenience to use where AC outlet is not available such as in more rural and underdeveloped areas. However, Notebook can drain it battery with heavy use in just a few hours, leaving the user searching for power outlet. With development of Solar Powered Notebook, the sun is the electricity needed to keep the Notebook running for hours longer where Solar or Photovoltaic (PV) Cells are used to collect solar energy for direct use to power up the Notebook. The design of the circuit can be summarized into four distinct circuits that work in tandem to generate the desired output of 20V from a solar panel input. The first is Boost Converter circuit to take in the input voltage from the solar panel and step up the voltage to the desired 20V as required by the Notebook. The second is timer circuit where it utilized the LM555 timer, which drives the MOSFET that operates as the switch in the Switch-Mode Boost Converter topology. The third is Active PFC Feedback circuit, this circuit allows for regulation of the output voltage so that the Boost Converter is only on for as long as necessary to maintain a voltage of 20V. Finally, there is the Voltage Clipper Circuit, which is the actual output voltage to the Notebook. This project suitable for scientists or researchers who work far away from civilization and power outlet. The Solar Powered Notebook proved to be energy saving because free energy, environmental benefits which reduce CO2 emissions associated with global warming and it works where there is no grid available.

# ABSTRAK

Notebook yang menggunakan kuasa bateri memberi manfaat di tempat-tempat yang jauh dari sumber kuasa a.u seperti di pedalaman dan kawasan-kawasan yang belum membangun. Walau bagaimanapun, kuasa bateri tidak mampu bertahan lama sekadar beberapa jam sahaja dengan penggunaan maksimum, menyebabkan pengguna terdesak untuk mencari sumber kuasa. Dengan projek *Solar Powered Notebook*, matahari merupakan tenaga elektrik yang diperlukan bagi menghidupkan Notebook lebih lama di mana *Solar* atau *Photovoltaic (PV) Cell* digunakan untuk mengumpul tenaga suria untuk digunakan secara terus bagi menghidupkan *Notebook*. Projek ini terdiri daripada empat litar yang saling berkait bagi menghasilkan keluaran 20V yang diperlukan oleh Notebook. Litar pertama adalah *Boost Converter* di mana ia mengambil voltan masukkan dari *solar panel* dan meninggikan voltan kepada 20V yang diperlukan oleh Notebook. Litar kedua ialah litar *timer* yang menggunakan *LM555 timer*, di mana memacu MOSFET berfungsi sebagai suis di dalam *Switch Mode Boost Converter*. Litar ketiga pula ialah litar *Active PFC feedback*, litar ini membenarkan perubahan voltan keluaran supaya *Boost Converter* akan berfungsi apabila diperlukan untuk menetapkan pengeluaran voltan 20V sahaja. Akhir sekali, litar *Voltage Clipper*, di mana memberi voltan sebenar kepada Notebook. Projek ini sangat penting dan sesuai kepada para saintis dan para pengkaji yang menjalankan tugasan jauh dari bandar atau sumber kuasa. Projek ini terbukti menjimatkan tenaga elektrik kerana menggunakan tenaga suria serta mengelakkan pencemaran kerana dapat mengurangkan pengeluaran tenaga $CO_2$ di stesen generator dan projek ini juga mampu berfungsi ketika jauh dari sumber grid.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| PFC | −Power Factor Correction |
| PV | −Photovoltaic |
| DC/dc | −Direct Current |
| SMPS | −Switch-Mode Power Supply |
| CCM | −Continuous Current Mode |
| GND | −Ground |
| MOSFET | −Metal–Oxide–Semiconductor Field-Effect Transistor |
| PWM | −Pulse Width Modulation |
| MPPT | −Maximum Power Point Tracker |
| CVC | −Constant Voltage Control |
| LED | −Light Emitting Diode |
| BIPV | −Building Integrated Photovoltaic |
| AC | − Alternating Current |
| PWM | −Pulse Width Modulation |
| $f$ | −Frequency |
| D | −Duty Cycle |
| L | −Inductance |
| C | −Capacitance |
| R | −Resistance |
| CCM | −Continuous Conduction Model |
| IC | −Integrated Circuit |

## LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

This part described introduction an overview of the research work. It will explain about overview of the project, problems statement, objectives and scope of work that must be done.

## 1.1 Overview of The Project

Solar or Photovoltaic (PV) is the one of the renewable energy resources that recently has become more popular in nowadays technologies. PV has many benefits especially in environmental, economic and social. In general, a PV system consist of a PV array which converts sunlight into direct-current (DC) source. There are many technologies for solar energy application through residential, commercial, industrial, agricultural and transportation sectors.

But in this project, DC source is used to power up the notebook. With development of solar powered notebook, the sun is the electricity needed to keep that notebook running for hours longer after the notebook battery run out. In this project, Solar or Photovoltaic (PV) cells are used to collect solar energy for direct use. Although there are numerous commercially available DC-to-DC converters available in market, most are costly. A combination of four simple circuits is combining to create a cheaper alternative to the commercially available DC-to-DC converters on the market. This project sure very useful for scientists or researchers who work far away from civilization and power source.

## 1.1 **Problems Statement**

As mentioned previously, Notebook can drain it battery with heavy use in just a few hours and power source is not available such as in more rural or undeveloped area to power the notebook. Therefore, since notebook required DC source, solar panel is the best solution.

## 1.3 Objectives

The aims of this project are:

i. To design and implement solar power supply system for the notebook using solar energy.

ii. To design and implement boost converter based of PWM to boost the supply voltage from 12VDC from solar panel to 20VDC.

## 1.4 Scope of Work

In this study, by using solar panel, it will produce 80W 17VDC 5A current output. In my design scope, the boost converter circuit will take in the 13VDC voltage and step up the voltage to the desired 20VDC as required by the FujiTsu Notebook model with the specification is 20VDC 3.25A 65W.

Second focused on the project is expected to deliver the power during the day time only and when sunlight is available.

## 1.5 Thesis Outline

This Development of Solar Powered Notebook thesis is arranged into following chapter:

Chapter 1 discuss on the background of the project, objectives, scope of the project, problem statement and also the thesis outline.

Chapter 2 focuses on literature reviews of this project based on journals and other references.

Chapter 3 main discuss on the system design of the project. Details on the progress of the project are explained in this chapter.

Chapter 4 presents the results of the project. The discussion focused on the result based on the experiment and performance of Development of Solar Powered Notebook.

Chapter 5 concludes overall about the project. Obstacle faces and future recommendation are also discussed in this chapter.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Power electronics is one of the broadest growth areas in electrical technology. Today, electronic energy processing circuits are needed for every computer system, every digital product, industrial systems of all types, automobiles, home appliances, lamps and lighting equipment, motor controllers, and just about every possible application of electricity (A.H.M.Yatim, 2006). T his chapter are the reviews about the study that have been done before developed the Solar Powered Notebook. Some of the systems look alike with the Solar Power Notebook project. Other, they are the study about the main components used.

## 2.2 Benefits of Photovoltaic Module (Solar Panel)

These days, energy crises are growing and all those countries which are blessed with sunlight can use solar energy for their household items and businesses. Solar energy is helping a lot of countries that have started developing solar polar for their convenience to save themselves from pollution. Investing in solar power will not be a wrong decision and it will be bringing a lot of fruitful results for stabilizing the economy of a country. The other benefits can be concluded below: [1]

i. Solar electricity can supplement or provide all your electrical consumption.
ii. Additional solar modules can be added later as demand or budget grows.
iii. Solar electricity is generated without emitting greenhouse gases.
iv. Solar panels or modules are silent, without any moving parts.
v. Solar modules can be integrated into the building in the form of windows, walls and roof tiles and known as Building Integrated PV (BIPV).
vi. A solar module should last for at least 20–30 years.

### 2.3 Types of Photovoltaic Module (Solar Panel)

Due to the growing demand for renewable energy sources, the production of solar cells and photovoltaic arrays has advanced dramatically in recent years. Practically there are three basic types of PV solar panels; which is Monocrystalline, Polycrystalline and Amorphous. The consumer can choose the types of PV based on their need and availability. For this project, Monocrystalline PV solar panel is chosen.

i. Monocrystalline cells are cut from a single crystal of silicon. They are basically a slice of crystal. This makes them very smooth in texture and can see the thickness of the slice. Monocrystalline cells are the most efficient, but also the most expensive to produce. They are completely rigid and must be mounted in a rigid frame for protection. Figure 2.1 below show Monocrystalline cells solar panel.

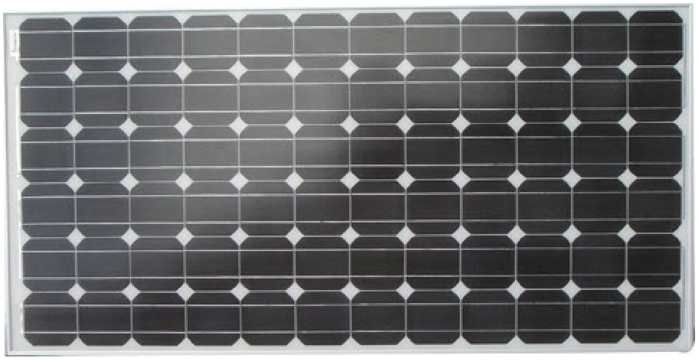


**Figure 2.1** Monocrystalline Solar Panel

ii. Polycrystalline (or Multicrystalline) cells as show in figure 2.2 are made from a slice cut from a block of silicon, but whereas Monocrystalline cells are from a single crystal, these cells consist of a large number of crystals. This gives them a speckled reflective appearance but, once again you can you see the thickness of the slice. Photovoltaic solar panels made from these types of cell are slightly less efficient but also slightly cheaper than Monocrystalline cells. They also need to be mounted in a rigid frame.

**Figure 2.2** Polycrystalline Solar Panel

iii. Finally, Amorphous cells are manufactured by placing a thin film of Amorphous (non crystalline) silicon onto a wide range of surfaces. These create the least efficient type of Photovoltaic solar panels but also the cheapest. Due to the Amorphous nature of the thin layer it is flexible, and if manufactured on a flexible surface, the whole Photovoltaic solar panel can be flexible. One problem with Amorphous cells, however, is that their power output reduces over time, particularly during the first few months, after which time they are basically stable. The quoted output of an Amorphous panel should be that produced after this period. Figure 2.3 below show Amorphous cells solar panel.

**Figure 2.3** Amorphous Solar Panel

## 2.4 Solar Power Supply System Using DC-DC Converter

The solar cell is now being used as power sources for radio relay stations, light houses, agricultural systems, microwave communication systems, and so forth. In such solar cell power supply systems, it often requires that the maximum power point of the solar array is tracked, in spite of the variations in the load and the sunlight intensity, to make the most efficient use of the solar array and the storage battery [2]-[6].

A MPPT is a power electronic DC/DC converter inserted between the PV module and load to achieve optimum matching. By using an intelligent algorithm, it ensures that the PV module always operates at its maximum power point. Several MPPT algorithms have been proposed in different literatures like Perturb & Observe (P&O), Incremental Conductance, Constant Voltage, Constant Current and fuzzy based algorithms [7]. These techniques differ in many aspects like complexity, convergence speed, hardware implementation, sensors required, cost, range of effectiveness and need for parameterization. The P&O and Incremental Conductance algorithms are more common due to effectiveness of extracting maximum power from the panel, ease of hardware implementation, and less sensor requirement and consequently relative low cost [5]. But is has problem of oscillation around the MPP, due to this there is considerable loss of power. Also the response of P&O algorithms is slow under fast changing environmental condition. Different converter topologies like buck, boost, buck-boost and cuk converters are implemented for MPPT design. Boost converter can track MPP with maximum efficiency and can work for wide range of input voltage [5]. However, other advantages like less component needed for hardware implementation and cost, makes this topology a better choice than the buck or buck-boost for MPPT system design.

### 2.4.1 Boost Type Bidirectional DC-DC Converter [2]

In this solar cell power supply system, the boost type bidirectional converter as a charger/discharger and the simple control circuit with a small monitor solar cell are used in order to track the maximum power point of the solar array. The key point to note is that in the system each converter processes the solar array output power in parallel, and that the short-circuit current of the monitor solar cell is made use of as a reference to detect the maximum power point.

The block diagram of the solar cell power supply system is shown in figure 2.4. In this system, the traditional unidirectional converter is used as a stabilizer and the bidirectional converter as a maximum power tracker. The operation of this system is divided broadly into two modes, which are called the charge and discharge modes. Figure 2.5(a) shows the block diagram in the charge mode of the system, and the discharge mode is divided further into two submodes as represented by the block diagrams of figure 2.5(b) and (c). Now we will give the consideration to these three modes; the charge mode, and the discharge modes I and II.

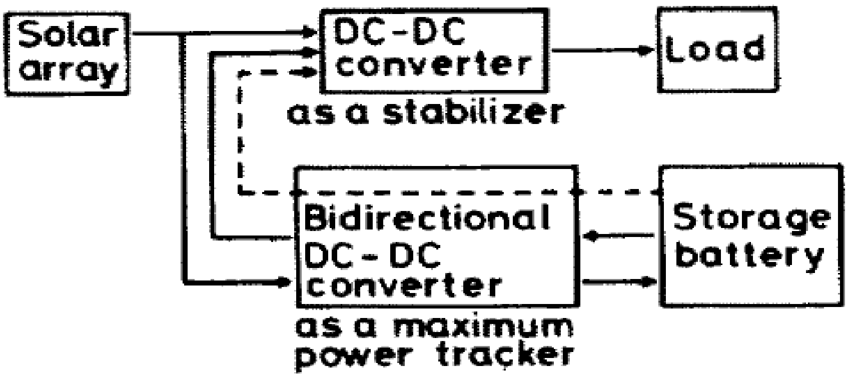
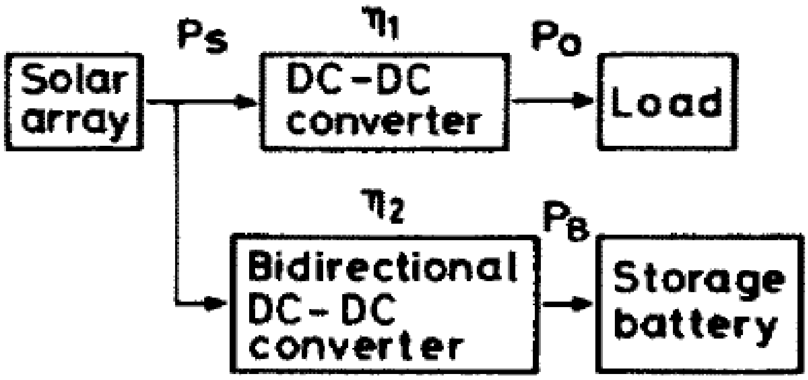
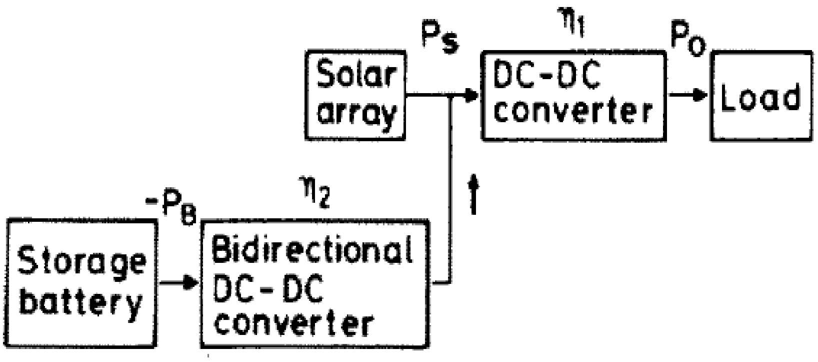


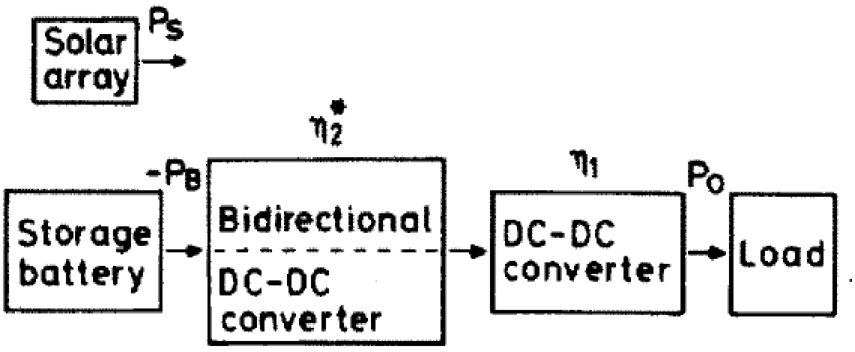

**Figure 2.4** Block Diagram of the Solar Power Supply System Using Boost Converter




(a)




(b)




(c)

**Figure 2.5** (a) Block diagram in the charge mode of the solar cell power supply system η1, and η 2 are the conversion efficiencies of the unidirectional and the bidirectional converters (b) Block diagram in the discharge mode I of the solar cell power supply system. (c) Block diagram in the discharge mode II of the solar cell power supply system.

First, when the light intensity $E_e$ is sufficiently high, the solar array output power $P_s$, is large and, in this case, the bidirectional converter operates in the charge mode, as illustrated in figure 2.5(a). In this mode, some amount of the power $P_s$ is transferred to the load only through the unidirectional converter and the excess power of $P_s$ is sent to and stored in the storage battery only through the bidirectional converter. Thus the solar array output power $P_s$ is processed by each converter in parallel.

Next, when the light intensity $E_e$ is so low that the solar array output power $P_s$ is less than the load power $P_o$, the bidirectional converter operates in the discharge mode and the storage battery takes over the load power in part as illustrated in figure 2.5 (b). The solar array output power $P_o$ is sent to the load through the unidirectional converter alone but the power -PB from the storage battery is processed by both of the bidirectional and the unidirectional converters in series.